INDOOR AIR QUALITY ASSESSMENT

Sherwood Middle School
30 Sherwood Avenue
Shrewsbury, Massachusetts 01545

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
January 2006

Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at the Sherwood Middle School (SMS), 30 Sherwood Avenue, Shrewsbury, Massachusetts. The request was prompted by parental concerns of general indoor air quality conditions, as well as concerns regarding the presence of rodents and their potential as a trigger for asthma.

On November 9, 2005, a visit to conduct an indoor air quality assessment was made by Cory Holmes, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. During the assessment, Mr. Holmes was accompanied by Nancy Allen, Director of the Shrewsbury Health Department (SHD) and Robert Moore, Health Agent for the SHD. Robert A. Cox, Superintendent of Public Buildings for the Town of Shrewsbury was also present for portions of the assessment.

The SMS is two-story brick building constructed in the early 1960s. In 1995, a wing containing ten modular classrooms was added; however, the majority of building components are original. The building contains general classrooms, science classrooms, a gymnasium, library, art rooms, music rooms, kitchen, cafeteria and administrative offices. Other than the addition of the modular classroom wing in 1995 and roof replacement to the original building (approximately 15 years ago), it appears that no major renovations have been made to the building.

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were conducted with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). MDPH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses approximately 850 students in grades 5 and 6 and a staff of approximately 75. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) parts of air in thirteen of twenty areas surveyed, indicating a lack of air exchange in the majority of areas surveyed during the assessment. Mainly due to mechanical ventilation components being deactivated, inoperable or obstructed.

Fresh air in classrooms is supplied by a unit ventilator (univent) system (Picture 1) installed with high efficiency pleated air filters. A univent is designed to draw air from outdoors through a fresh air intake located on the exterior wall of the building and return air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed and filtered, then heated and provided to classrooms through an air diffuser located in the top of the unit. Univents are reportedly original equipment, over 40 years old. Univents of this age can be difficult to maintain because replacement parts are often unavailable. Univents were operating in all areas surveyed during the assessment. However, obstructions to airflow, such as papers and books stored on univents and bookcases, carts and desks in front of univent returns, were seen in several classrooms. In order for univents to provide fresh air as designed, univent air diffusers and return vents (located along the front of units) must remain free of obstructions.

Exhaust ventilation in classrooms is provided by ducted, grated wall or ceiling vents (Pictures 2 and 3) powered by rooftop motors. Several rooftop exhaust vents were on order to be repaired; therefore, no means of mechanical exhaust for these classrooms was being provided during the assessment. A number of exhaust vents were also obstructed by desks, bookcases and other items (Picture 2). As with the univents, in order to function properly, exhaust vents must be activated and remain free of obstructions. In addition, the location of some exhaust vents can limit exhaust efficiency. In several rooms, exhaust vents are located near hallway doors. When these classroom doors are open exhaust vents become blocked (Picture 4). Exhaust vents in these rooms will also tend to draw air from both the hallway and the classroom, reducing the effectiveness of the exhaust vent to remove common environmental pollutants.

Ventilation for modular classrooms is provided by AHUs (Picture 5). Fresh air is distributed to classrooms via ductwork connected to ceiling-mounted air diffusers (Picture 6) and drawn back to the AHUs through return grilles. Thermostats control each heating, ventilating and air conditioning (HVAC) system and have fan settings of "on" and "automatic". Thermostats were set to the "automatic" setting (Picture 7) during the assessment. The automatic setting on the thermostat activates the HVAC system at a preset temperature. Once the preset temperature is reached, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, consult Appendix A.

Temperature measurements ranged from 66^{o} F to 76^{o} F; classroom temperatures were within the MDPH recommended comfort range in all but two classrooms. The MDPH recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents and exhaust vents inoperable/obstructed/deactivated).

The relative humidity measured in the building ranged from 23 to 47 percent, which were within the MDPH recommended comfort range in all but three areas the day of the assessment. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several potential pathways for moisture to enter the building were identified, most notably around window frames (Picture 8). Historic water damage as evidenced by peeling paint, crumbling plaster and efflorescence was observed throughout the building (Pictures 9 to 11). Efflorescence is a characteristic sign of water damage to brick and mortar, but it is not mold growth. As moisture penetrates and works its way through mortar and brick, water-soluble compounds in mortar and brick dissolve, creating a solution. As the solution moves to the surface of the mortar or brick, the water evaporates, leaving behind white, powdery mineral deposits. Replacement of caulking and repairs of window leaks are necessary to prevent water penetration and subsequent damage to building materials, which can lead to mold growth and associated odors.

Several subterranean pits were located along the perimeter of the building. These pits allow air to flow below grade into air intakes for the mechanical ventilation system. Leaves, papers and other debris were observed on the floor of these pits (Picture 12). Such debris can provide a source of mold growth.

MDPH staff also observed missing/damaged downspout extensions on the modular classroom wing and open utility holes in exterior walls in brickwork along the rear of the main building. Water accumulation/penetration can result in the chronic wetting of building materials and potentially lead to microbial growth. In addition, holes in exterior walls may provide a means of egress for pests/rodents into the building.

Several classrooms contained a number of plants. Plants, soil and drip pans can serve as sources of mold growth, and thus should be properly maintained. Plants should have drip pans to prevent wetting and subsequent mold colonization of window frames. Plants should also be located away from ventilation sources to prevent aerosolization of dirt, pollen or mold.

Other IAQ Evaluations

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it is present, indoor carbon monoxide levels should be less than or equal to outdoor levels. For the SMS, indoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured outside the school were also ND.

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particulate levels be maintained below 65 μg/m^3 over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 7 μg/m^3 (Table 1). PM2.5 levels measured indoors ranged from 7 to 40 μg/m^3, which were below the NAAQS PM2.5 level of 65 μg/m^3 in all areas. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner; and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Indoor TVOC measurements throughout the building were ND. Outdoor TVOC concentrations were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC-containing products. While no measurable TVOC levels were detected in the indoor environment, VOC-containing materials were noted. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Several other conditions that can affect indoor air quality were noted during the assessment. As discussed, occupants expressed concerns about possible presence of rodents and health issues that can be associated with their wastes and dander. School officials reported that the school has issues with occasional rodents and under state regulations has undergone an integrated pest management plan to prevent/reduce the presence of rodents.

Rodents can be a source of disease and infestation can result in indoor air quality related symptoms due to materials in their wastes. Mouse urine and feces contain a protein that is a known sensitizer (US EPA, 1992). A sensitizer is a material that can produce symptoms (e.g. rhinitis and skin rashes) in sensitive individuals.

A three-step approach is necessary to eliminate rodent infestation:

1. removal of the rodents;
2. cleaning of waste products from the interior of the building; and

3. reduction/elimination of pathways/food sources that are attracting rodents such as toasters/toaster ovens in classrooms.

Although no evidence of rodents was observed during the assessment, several potential pathways for rodents to enter the building were identified, such as open utility holes in exterior brickwork and spaces around exterior doors.

The art room contains a kiln that is ducted out of the building in the general vicinity of a univent air intake (Pictures 13 and 14). Because the kiln exhaust vent empties downward *towards* the air intake, the possibility of re-entrainment of kiln exhaust is possible depending on certain wind and weather conditions.

In some classrooms, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. Accumulated dust was observed on the blades of personal fans and on exhaust vents in several classrooms (Pictures 15 and 16). If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles. The fan blades should be vacuumed periodically to prevent aerosolization when fans are activated. Dust can be irritating to eyes, nose and respiratory tract.

Finally, occupants expressed concerns regarding the condition of floor tiles in the hallway outside of classroom 121 (Picture 17). Floor tiles of this type and age often contain asbestos. Intact asbestos-containing materials (ACM) do not pose a health hazard. If damaged, ACM can be rendered friable and become aerosolized. Considering that tiles are predominately in the hallways, materials from broken tiles are more likely to be aerosolized in there high traffic areas. Friable asbestos is a chronic (long-term) health hazard, but will not produce acute (short-term) health effects (e.g., respiratory symptoms, headaches) typically associated with buildings perceived to have indoor air quality problems. Where ACM are found damaged, these materials should be removed or remediated in a manner consistent with Massachusetts asbestos remediation laws (MDLI, 1993).

In regards to ACM, Mr. Cox reported that the SMS is in compliance with the Asbestos Hazard Emergency Response Act (AHERA), which requires inspection of asbestos containing materials every three years. In addition, a semi-annual walkthrough is conducted to determine current conditions of ACM. AHERA requires public and private non-profit primary and secondary schools to inspect their buildings for asbestos-containing building materials and to develop, maintain and update an asbestos management plan to be kept at the school.

Conclusions/Recommendations

Although no evidence of rodents was identified during the assessment, several issues were identified that could attract or provide an entry for rodents and other pests into the building. In additions, the general building conditions, maintenance, work hygiene practices and the condition/age of HVAC equipment, if considered individually, present conditions that could degrade indoor air quality. When combined, they can serve to further degrade indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons, a two-phase approach is required for remediation. The first consists of **short-term** measures to improve air quality and the second consists of **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns.

The following **short-term** measures should be considered:

1. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers throughout the school.
2. Operate all ventilation systems that are operable throughout the building continuously during periods of school occupancy and independent of thermostat control. To increase airflow in classrooms, set univent controls to “high”.
3. Inspect exhaust motors and belts for proper function. Continue with plans to repair and replace as necessary.
4. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
5. Consider setting thermostat controls in modular classrooms to the “on” position to provide constant supply and exhaust ventilation during periods of occupancy.
6. Use openable windows in conjunction with classroom univents and exhaust vents to increase air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
7. Consider balancing mechanical ventilation systems every 5 years, as recommended by ventilation industrial standards (SMACNA, 1994).

8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
9. Seal utility holes/breaches in exterior walls and install weather stripping around exterior doors to prevent water penetration, drafts and pest entry.
10. Replace missing elbows to downspouts in a manner to direct rainwater away from the building.
11. Move plants away from univents in classrooms. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.
12. Remove leaves and debris from subterranean pits seasonally.
13. Vacuum interior of univents during regular filter changes to prevent the accumulation/aerosolization of dirt, dust and particulates.
14. Clean accumulated dust from blades of personal fans and exhaust vents on a regular basis.
15. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

16. Use the principles of integrated pest management (IPM) to rid the building of pests. Activities that can be used to eliminate pest infestation may include the following activities.

- Do not use recycled food containers. Seal recycled containers in a tight fitting lid to prevent rodent access.
- Remove non-food items that rodents are consuming.
- Stored foods in tight fitting containers.
- Avoid eating at workstations. In areas were food is consumed, periodic vacuuming to remove crumbs are recommended.
- Regularly clean crumbs and other food residues from toasters, toaster ovens, microwave ovens coffee pots and other food preparation equipment. Consider relocating this equipment from classrooms to break room/kitchen areas.
- Examine each room and the exterior walls of the building for means of rodent egress and seal appropriately. Holes as small as ¼" is enough space for rodents to enter an area. If doors do not seal at the bottom, install a weather strip as a barrier to rodents.
- Reduce harborages (e.g., cardboard boxes) where rodent may reside.

A copy of the IPM Guide can be obtained at the following Internet address: http://massnrc.org/ipm/docs/ipmkitforbuildingmanagers.pdf

17. Remove or remediate damaged floor tiles in conformance with Massachusetts asbestos remediation and hazardous waste disposal laws.

18. Consider relocating or extending local exhaust vent for kiln to prevent the entrainment of exhaust into the univent air intake for the art room.

19. Consider developing a written notification system for building occupants to report indoor air quality issues/problems, if one is not already in place (Appendix B). Ensure concerns are relayed to the maintenance department/ building management in a manner to allow for a timely remediation of the problem.
20. Consider adopting the US EPA (2000b) document, "Tools for Schools", to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.
21. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website: http://mass.gov/dph/indoor_air

The following **long-term** recommendations should be considered.

1. Replace/repair window systems throughout the building-wide to prevent water penetration and drafts through window frames. Consider having exterior brick re-pointed and waterproofed to prevent water intrusion. Weatherproofing materials should be applied during periods when the school is not occupied.
2. Contact an HVAC engineering firm for an assessment of the ventilation system's control system (e.g., controls, air intake louvers, thermostats). Based on the age, physical deterioration and availability of parts for ventilation components, such an evaluation is necessary to determine the operability and feasibility of repairing/replacing the equipment.

References

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-1989

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL. Section M-308.1.1.

MDLI. 1993. Regulation of the Removal, Containment or Encapsulation of Asbestos, Appendix 2. 453 CMR 6,92(I)(i).

MDPH. 1997. Requirements to Maintain Air Quality in Indoor Skating Rinks (State Sanitary Code, Chapter XI). 105 CMR 675.000. Massachusetts Department of Public Health, Boston, MA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

US EPA. 1992. Indoor Biological Pollutants. US Environmental Protection Agency, Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, research Triangle Park, NC. EPA 600/8-91/202 January 1992.

US EPA. 2000a. National Ambient Air Quality Standards (NAAQS). . US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. http://www.epa.gov/air/criteria.html.

US EPA. 2000b. Tools for Schools. Office of Air and Radiation, Office of Radiation and Indoor Air, Indoor Environments Division (6609J). EPA 402-K-95-001, Second Edition. http://www.epa.gov/iaq/schools/tools4s2.html\

Picture 1

Classroom Univent, Note Box, Pencil Sharpener and Other Items on Unit

Picture 2

Wall-Mounted Exhaust Vent Obstructed by File Cabinet

Picture 3

Ceiling-Mounted Exhaust Vent in Science Classroom

Picture 4

Exhaust Vent behind Open Hallway Door

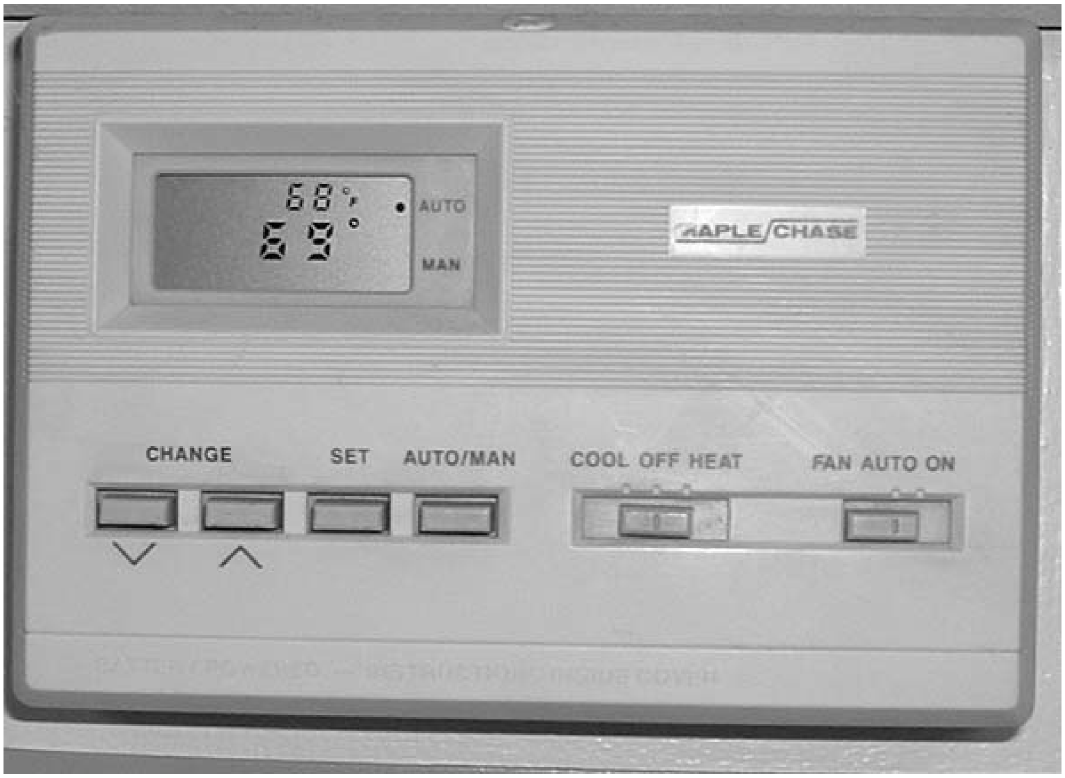
Picture 5

Rooftop AHUs for Modular Classrooms

Picture 6

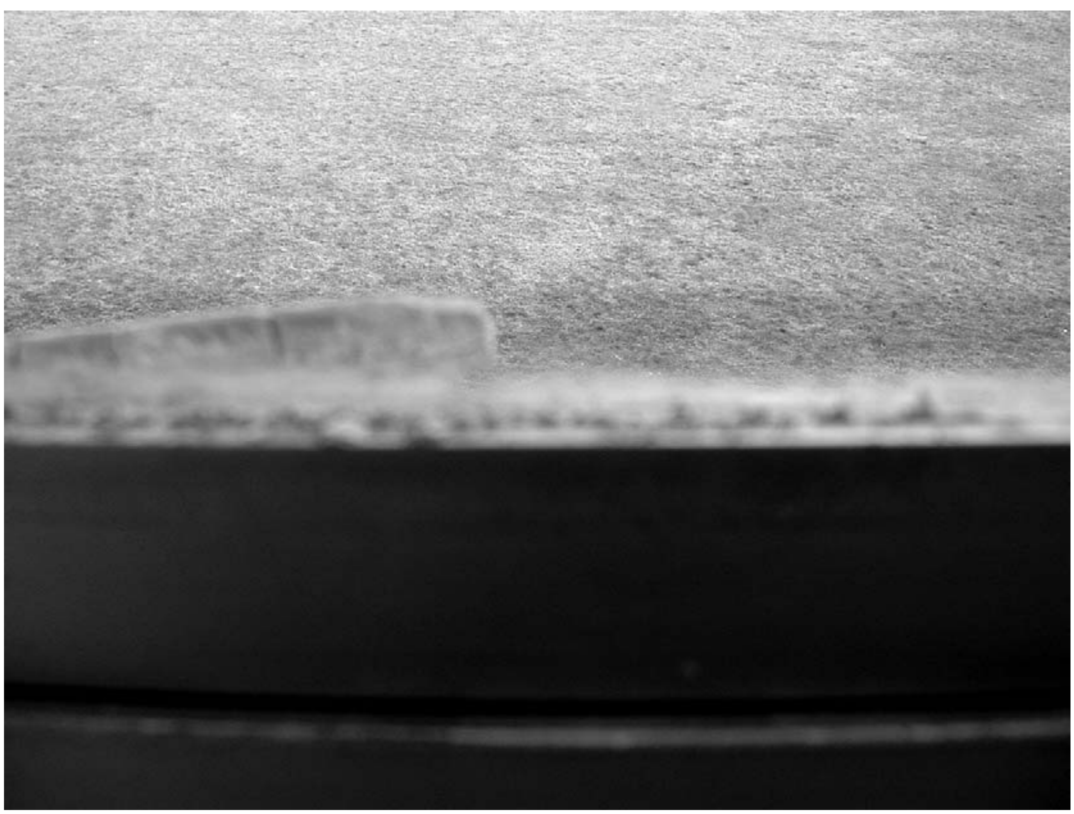
Ceiling-Mounted Vent in Modular Classroom, Note Both Supply and Return Use Similar Vents

Picture 7



Modular Classroom Thermostat, Note Fan is in "Auto" Position

Picture 8



Missing/Damaged Window Caulking

Picture 9

Water Damaged Ceiling Plaster above Window Frames

Picture 10

Water Damaged Wall Plaster near Window Frames

Picture 11

Water Damaged Wall Plaster near Window Frames

Picture 12

Plant Growth and Debris in Subterranean Pit

Picture 13

Kiln in Art Room Vented to the Outside

Picture 14

Exterior View of Kiln Exhaust and Univent Air Intake

Picture 15

Dust Accumulation on Fan Blades

Picture 16

Dust Accumulation on Exhaust Grill

Picture 17

Damaged Hallway Floor Tiles near Classroom 121

Shrewsbury Middle School

30 Sherwood Avenue, Shrewsbury, MA 01545

Table 1

Indoor Air Results

Date: 11/09/2005

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
background	0	47	25	384	ND	ND	7	N			cool, mostly sunny, scattered clouds, NE winds 10-15 mph.
cafeteria	250	71	29	1260	ND	ND	40	N	Y ceiling	Y ceiling	
gym	45	66	25	666	ND	ND	14	N	Y wall (off)	Y ceiling (off)	Hallway DO, Exterior DO,
006	19	71	30	1076	ND	ND	10	Y # open: 0 # total: 6	Y univent	Y wall (weak)	WD-WP, WD-CP, DEM, cleaners, plants.
016 art	25	72	31	1289	ND	ND	38	N	Y univent	Y wall (off)	Kiln exhaust near UV intake, plants in subterranean pit.
017 art	24	73	26	963	ND	ND	36	N	Y univent	Y wall (off)	Hallway DO, PF.
027	1	73	23	541	ND	ND	8	Y # open: 0 # total: 6	Y univent plant(s)		PF, plants, 25 occupants gone 30 mins.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Shrewsbury Middle School

30 Sherwood Avenue, Shrewsbury, MA 01545

Table 1

Indoor Air Results

Date: 11/09/2005

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
027 B	26	70	28	796	ND	ND	10	Y # open: 0 # total: 6	Y univent	Y wall	DEM.
106 Modular	26	72	47	2488	ND	ND	30	Y # open: 0 # total: 4	Y ceiling (off)	Y ceiling (off)	DEM
110 Modular	20	71	42	2465	ND	ND	30	N	Y ceiling (off)	Y ceiling (off)	DEM.
111 Modular	1	73	40	2182	ND	ND	33	Y # open: 0 # total: 4	Y ceiling	Y ceiling	7 occupants gone 10 mins.
118	23	71	26	692	ND	ND	17	Y # open: 1 # total: 6	Y univent items dust/debris	Y wall	DEM, PF.
121	22	71	30	1241	ND	ND	13	Y # open: 0 # total: 6	Y univent	Y (off) location	DEM.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

<u>Shrewsbury Middle School</u> **Indoor Air Results**

30 Sherwood Avenue, Shrewsbury, MA 01545 **Table 1** **Date: 11/09/2005**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
125	22	72	29	1134	ND	ND	23	Y # open: 0 # total: 0	Y univent items	Y wall	
137	24	75	32	1201	ND	ND	24	Y # open: 1 # total: 6	Y univent	Y wall	DEM, PF, items, plants, large pillows on floor.
138	22	71	31	1298	ND	ND	35	Y # open: 0 # total: 6	Y univent	Y wall (off)	WD-ceiling, WD-WP, DEM, plants, efflorescence/peeling paint walls near windows.
139	24	66	32	1074	ND	ND	16	Y # open: 0 # total: 12	Y univent items	Y ceiling (off)	WD-WP, DEM, PF, exhaust vent in storage closet-passive vent in door.
234	27	70	30	691	ND	ND	14	Y # open: 0 # total: 6	Y univent plant(s)	Y wall furniture	WD-CP, DEM, plants.
235	21	70	22	784	ND	ND	15	Y # open: 0 # total: 6	Y univent	Y wall (off) furniture	DEM, items, microwave, refrigerator, pleated filters in UV, debris in floor of UV cabinet.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Shrewsbury Middle School

30 Sherwood Avenue, Shrewsbury, MA 01545

Table 1

Indoor Air Results

Date: 11/09/2005

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
236	24	76	35	2089	ND	ND	21	Y # open: 0 # total: 6	Y univent	Y wall furniture	WD-WP, DEM, plants.
237	23	72	28	793	ND	ND	7	Y # open: 0 # total: 6	Y univent	Y wall	WD-WP, DEM.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%